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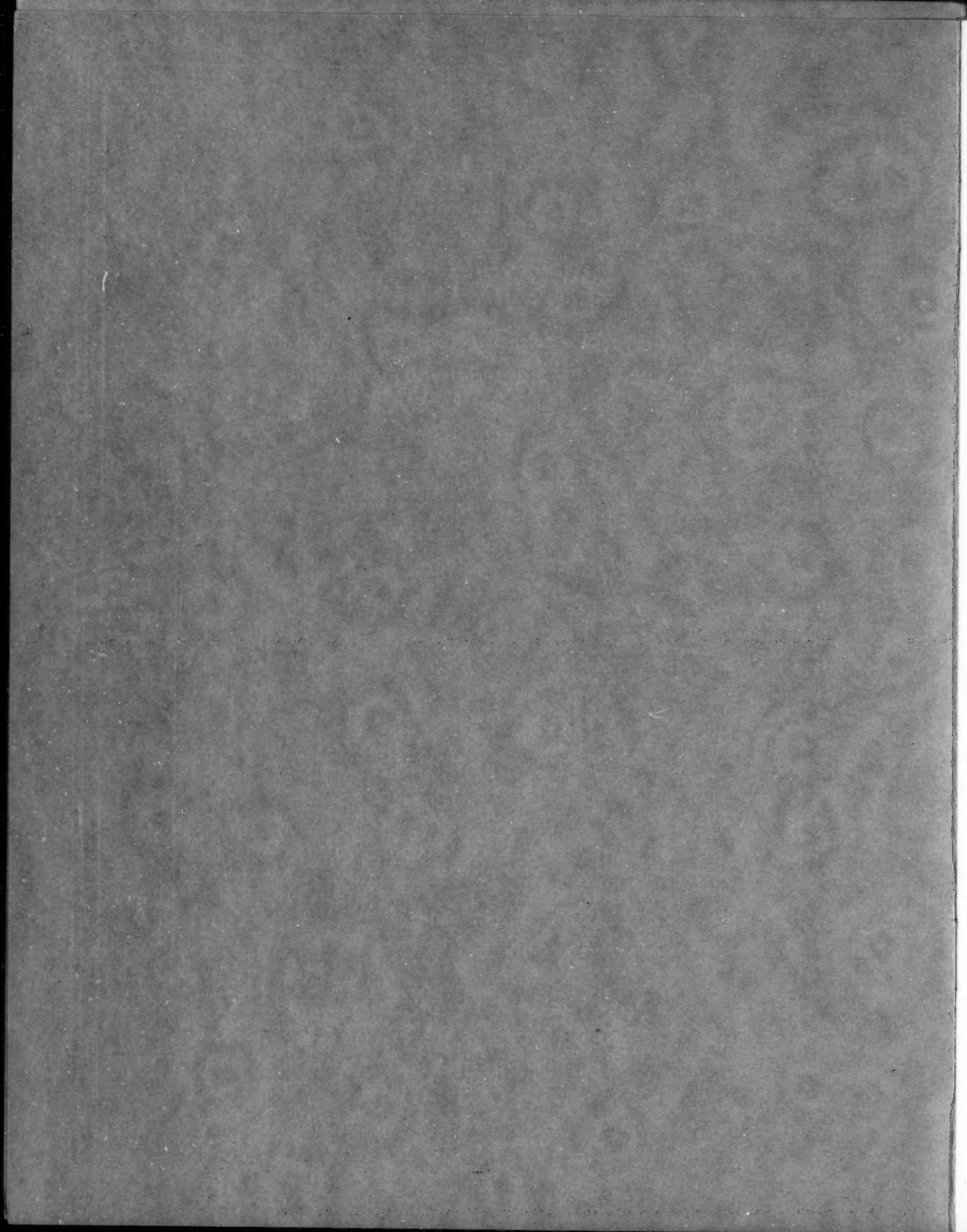
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The Bituminous Macadam Pavement

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THE bituminous macadam pavement consists of crushed stone and bituminous material incorporated together by penetration methods. Ordinarily, the surface course, only, is penetrated to a depth of 2 to 3 inches with either tar or asphalt, and the base course consists of crushed stone with or without bituminous binder, hand-placed stone, concrete, old macadam or old gravel surfaces. Under the base course a foundation course is frequently constructed consisting of crushed stone, hand-placed stone, gravel or stone fill. A blanket course of fine, granular material is also sometimes used under the foundation course or under the base course.

Although the merits and usefulness of bituminous macadam pavement are well known in many localities, they are not yet fully realized in others. It is a comparatively new type of construction and was developed to produce a road surfacing which would not ravel under automobile traffic and which would be dustless. When properly designed and carefully constructed, it is an excellent pavement, well fitted for the needs of present day traffic. Its use is growing on our principal highway systems and it has become so important that earnest effort should be devoted to its highest development and to a wide dissemination of information on the best methods for its construction. It is the aim of the present article to give helpful facts to those interested in bituminous macadam pavements.

In the April 1 and June 1, 1926, issues of The Crushed Stone Journal articles were published dealing with some of the theoretical considerations involved in the design of bituminous macadam. The present article treats of the more practical phases of this type and of the methods for its successful construction.

Foundations and Drainage

Ordinarily, the road will be made up of a foundation course which may be from 4 to 18 inches in thickness,

a base course of 3 to 4 inches and a surface course of 2½ to 3 inches thick.

A foundation course is not always necessary. For instance, if the soil is a compacted gravel, well able to support heavy loads when wet, it is useless to provide a foundation course. The road will then consist merely of a base course and of a surface course. Similarly, a suitable foundation course may already exist in the form of an old stone or gravel road.

If the road is to be constructed over a subgrade of uniform characteristics, no great difficulty will be presented in the design of the foundation, which may then be uniform in character; but in some localities such a condition of uniformity does not exist. Very frequently the subgrade will change suddenly from hard gravel to pockets of plastic clay and from a very well drained condition to wet, spongy spots. Sometimes the road will follow an old, compacted macadam or gravel road and at others will be built on an entirely new grade. Each section of road presents a separate problem which demands detailed study. It is most important that every effort be made to obtain a solid, non-yielding foundation, for the success of the surface course is largely dependent upon the foundation.

When the bituminous macadam surface is to be built over an old macadam or gravel road, a field inspection of the old road will reveal the weak spots which need strengthening and those which need drainage. *A very good time to make a preliminary inspection of the old road is during winter thaws.* Notes should be taken giving a complete description of the conditions found. This preliminary inspection will reveal the location of weak spots but a subsequent inspection is needed to determine the proper means for drainage. *This inspection should be made in the spring of the year, for at that time the greatest amount of water is found and some wet spots appear only during that period.* After the second inspection the details of the

sub-soil drainage should be designed. A careful survey should also be made of the materials available for foundations. Among these may be mentioned sand, gravel, field stone, crushed stone, stone screenings, cinders and slag.

Blanket Course

The selection of the type of foundation material to be employed should be governed by the question of economy and suitability of the material for the particular conditions to be met. Sand, sandy gravel, stone screenings, cinders and similar material are useful as a blanket course under a foundation course of crushed stone or hand-placed stone. Particularly is this so where the sub-soil is of a plastic nature, for a blanket course will be of great assistance in preventing the clay from working up through the voids in the stone foundation to the detriment of its stability.

Types of Foundations Used

The following types of foundation courses are used to a great extent throughout the United States:

1. Crushed stone.
2. Waterbound macadam.
3. Stone fill.
4. Bank gravel.

1 and 2. Crushed Stone and Waterbound Macadam Foundation Course

Crushed stone is very generally used as a foundation course. If laid on a new sub-grade, a 3-inch compacted layer of screenings, cinders or other granular material is beneficial but may be omitted if the sub-soil is not of a very plastic nature. It is always well to maintain a new subgrade with small sized crushed stone or crushed gravel as a traffic bound road for several months or a year before laying the foundation course so that the weak places may be corrected and proper drainage supplied. The subgrade is greatly strengthened by the addition of the small stone and, moreover,

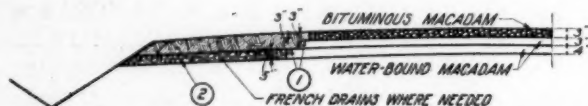


Fig. 1.—An Improved Design for Bituminous Macadam Roads
The features of this design are:

1. Stepped construction at edge to obtain better distribution of subgrade pressures.
2. Wide French drains where needed to promote dry subgrade.

the foundation course will thus be protected from clay intrusion from beneath.

Size of Crushed Stone for Foundation Course

The following sizes of stone are specified for the

foundation course with good results in the respective localities in which they are used, 1 to 2½ inches, or 2½ to 4½ inches and even larger sizes are used successfully.

The stone is rolled in layers not exceeding six inches in thickness and is then filled with small stone screenings or sometimes with sand or small gravel. It is important that the spreading and rolling be such that uniformity of compaction and surface contour will result, with as few inequalities as possible, for such inequalities will become evident in the surface of the pavement in the course of time. *No filling material should be used until the layer of stone has been rolled to wedge it tightly into position.* Then it may be filled with stone screenings and the rolling and filling continued to thorough compaction. The specifications given under broken stone and water-bound macadam base course apply equally well to the foundation course.

Proper Width of Foundation Course

At one time it was the practice to make the foundation course no wider than the width of the surface, and this erroneous practice is still followed in some localities. It has been already pointed out (see page 1 in the June 1, 1926, Crushed Stone Journal) that the pavement should be designed to provide as much strength at the sides as at the center. One of the means for accomplishing this is to extend the foundation course and also the base course out beyond the surface course as shown in Fig. 1. *The foundation course should extend at least six inches beyond the base course to properly spread the wheel load pressures to the subgrade.*

3. Stone Fill Foundation Course

A stone fill foundation is constructed with hand-placed stone of 3 inches to 12 or 15 inches in longest dimension and of a diameter smaller than the thickness of foundation desired. The larger stones are laid on the bottom in such a manner that they will not rock under the roller. The smaller stones are used on top, and during the rolling process the more rounded stones may have to be sledged to break them and permit of easier compaction under the roller. The voids in the foundation should be filled with fine crushed stone or screenings or sandy gravel. Rolling of the foundation course of hand-placed stone should continue until there is no noticeable movement under the roller. Uniformity both in compaction and smoothness of surface are essential in the foundation course. It is bad practice to depend upon smoothing out large local inequalities in the foundation by means of a variable thickness of base course because unequal compaction of the base

course is apt to result and a rough riding surface may later develop. The foundation course should be smooth enough to ride on at fairly high speeds and the filling material of crushed stone or sandy gravel should fill all the voids and be spread smoothly over the surface. Rolling of the foundation course is continued after the application of the filler and more filler is added during rolling to thoroughly fill the surface voids. As before noted, a blanket course of sandy gravel, stone screenings, cinders or similar material is of decided value under a stone fill foundation where the subsoil is of a plastic nature.

4. Gravel Foundation Course

A gravel foundation is often used, particularly over bad spots in the subgrade, sometimes up to 18 inches in thickness. As clay, when wet, is detrimental to the stability of gravel, it will be well to limit the permissible percentage of clay and silt to 15 per cent. There should also be a minimum of 40 per cent retained on the 1-inch screen to aid in providing stability. Not more than 25 per cent of particles passing a $\frac{1}{2}$ -inch screen should pass a No. 40 sieve. The maximum size should be not over 6 inches.

Variation in Design of Foundation Course

In some sections of the country where there is great variation in subgrade conditions, and likewise considerable variation in the character of materials available, the foundation course is frequently changed considerably in design. At the present time no rational method is available for determining the proper depth of foundation material and the judgment of the engineer, guided by his observation of the conditions, must be relied upon.

Base Course

By base course is meant the course upon which the surface course is supported. The base course may rest either directly upon the subgrade, in which case it serves the function of both the foundation and the base course, or it may be supported upon the foundation course. Generally it consists of a layer of crushed stone, rolled and filled with screenings, applied with or without water. If compacted without water, it is known as a broken stone base course; if with water, as a waterbound macadam base course. Sometimes the base course is penetrated with bituminous material and is then known as a bituminous macadam base. Still another form of base course is the hand-placed coarse stone base. Such a base is made not less than 8 inches in thickness, and serves the purpose of a foundation course and base course combined.

Broken Stone and Waterbound Macadam Base Course

Side Forms for Base Course

Before beginning the actual construction of a base course, side forms should be spiked into position on the foundation course and backed up with earth which subsequently forms the road shoulder. (See Fig. 2.) Careful attention should be given to set the forms properly, both as in line and grade. The thickness of the base course is generally 4 inches but may be



Fig. 2.—The side forms should be backed up with shoulder material.

varied, depending upon the conditions governing the design. The side forms are often omitted but they

are of very great assistance in obtaining the proper cross-section.

Size of Stone for Base Course

The size of stone generally used varies with the hardness and toughness. Thus, in New England where trap rock is prevalent, the base course of stone extends from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in size. In the Middle West where limestone abounds, better results are obtained with larger size material, generally extending from $2\frac{1}{2}$ to 3 $\frac{1}{2}$ or 4 inches and larger, measured by circular opening, laboratory screens. The larger sizes are desirable when the softer stones are used because of their greater tendency to crush under the roller. Excellent results are obtained, however, with both the hard and soft stones in their respective localities when properly used.

Quality of Stone for Base Course

The stone should consist of clean, durable fragments free from an excess of flat elongated, soft or disintegrated pieces, dirt or other objectionable matter.

The percent of wear should be not more than 8.0 and preferably 7.0. When the per cent of wear exceeds 4.0 it will be well to use a size of $2\frac{1}{2}$ to $3\frac{1}{2}$ or 4 inches and $1\frac{1}{2}$ to $2\frac{1}{2}$ inches for stone harder than this, although there is some question if the larger size will not also be better for the harder stone.

Spreading the Stone

Uniformity in the spreading is very essential if a smooth riding road is to be obtained, and an efficient type of spreader should by all means be employed. One type of such a spreader is illustrated in Figs. 3 and 4. This spreader consists of a hopper supported on wheels or runners and having a rectangular opening in the rear, adjustable to the thickness of layer of loose stone desired. In operation, the loaded motor

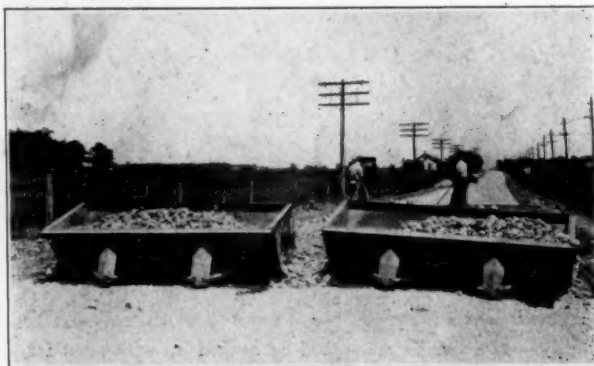


Fig. 3.—One type of stone spreader.

truck, having a dump body, backs up to the spreader which is then chained to the truck. The truck body

is raised and the stone is allowed to flow into the hopper. The truck then is started forward slowly, the

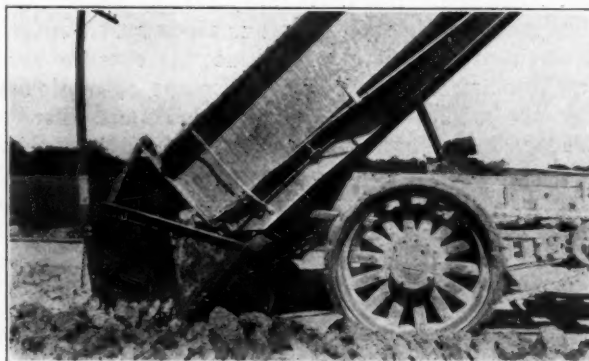


Fig. 4.—Detail of stone spreader; the stone is spread in a layer of uniform thickness as the truck moves forward slowly.

stone flowing continuously, thus keeping the spreader hopper full. As the spreader is drawn forward, the stone flows out of the rectangular opening in the rear and is deposited on the foundation in a layer of uniform thickness. The truck should be stopped as soon as it is empty but while the hopper of the spreader is still full. In this way the stone flowing from the spreader will always be under constant head and will flow out at a uniform rate. Such would not be the case if the hopper were allowed to be partially emptied.

Sometimes mechanical spreaders are not required by the specifications, in which case the stone should be spread with forks from piles along the sides of the roadway or from dumping boards, or directly from trucks, provided this is done in a uniform manner. In no case should the stone be dumped directly on the subgrade from trucks to be later spread from the piles thus formed, unless it is entirely re-handled. The spreading should not advance more than an average day's work in advance of the rolling and filling.

A little thought will show why it is so very important that the subgrade or foundation course be brought to as smooth a condition as possible before any stone is spread. Then only will the stone, as deposited from the spreaders, be in a condition such that uniformity of compaction and smoothness of surface of the base course will result.

Specifications for Broken Stone Base Course and Waterbound Base Course

The following very excellent specifications are quoted from the general specifications from the Maintenance Division of the Indiana State Highway Department for Waterbound Base Course.

Spreading Coarse Aggregate. Upon the foundation, which shall be clean and free from dirt, mud or other foreign material, shall be spread the coarse aggregate, to a sufficient depth to make the finished thickness specified. Side forms that are straight and of uniform dimension, held firmly to proper line and grade, shall be used to fix the depth of the loose material. In spreading, care must be taken to preserve the grade and crown; also to prevent a wavy surface. After the coarse aggregate is spread upon the foundation, unless the surface is smooth and uniform, it shall be harrowed with a heavy spike-tooth harrow having about 6-inch teeth, and leveled by hand, until a uniform and even surface prevails. When the amount of stone required at any one place is more than 6 inches in depth, it shall be spread, rolled and filled in two or more courses.

Great emphasis shall be laid upon the proper spreading of the stone so as to prevent any irregularities appearing in the finished surface. The smoothness of the surface shall be tested with an 18-foot straight-edge laid parallel with the center line of the road, and with a templet cut to the required cross-section laid transversely across the road.

All patches or areas of fine or undersized materials, appearing in this course, shall be removed and replaced with suitable material before final filling and waterbinding.

Roller. The rollers used in this work shall be self-propelled, three wheel rollers weighing not less than 10 tons. The pressure produced on the road surface by the rear wheels shall not be less than 410 lbs. per lineal inch of width of wheel. The roller wheels shall not be crowned more than $2\frac{1}{2}$ inches in 18 feet. All wheels shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean. The roller shall be equipped with water tanks and sprinkling devices which shall be used when necessary to wet the wheels and prevent the bituminous material from sticking to them. The roller shall be kept in good mechanical condition at all times, so that it can be started and stopped without jerking which would displace the stone. The steering device shall be such as will respond readily to the will of the operator so that the roller can be directed on the alignment desired. Steam rollers shall be equipped with suitable ash pans which shall be so designed as to prevent any ashes from falling upon the road surface. Motor rollers shall be equipped with suitable drip pans that will prevent any oil or gas from dropping upon the road surface.

Rolling. The rolling shall begin with the outside drive wheel covering equal parts of metal and shoulder and the roller shall be run forward and backward until the shoulder and metal are firmly bound together. When the shoulder and sides of the macadam have been firmly rolled, the rolling shall progress gradually toward the center from each side until the entire course has been thoroughly keyed and the interstices of the metal reduced to a minimum and all settlement has ceased. Depressions which become noticeable during the rolling, shall be eliminated by spreading additional coarse stone, in the required amounts before the rolling is completed. The shoulders shall be carefully rolled and refilled to the proper grade for a width of two feet.

Applying Screenings. After the coarse aggregate has been thoroughly dry rolled as described above, screenings shall be applied gradually over the surface during the finishing process of dry rolling in such an amount as will completely fill the interstices. The screenings shall not be dumped on the surface of the stone, but shall be cast thinly with a spreading motion of the shovel either from piles at the roadside or from light trucks. The rolling shall continue while the screenings are being spread, so that the jarring effect of the roller will cause them to settle to the bottom. The screenings shall be applied in three or more applications and at no time shall they be applied so fast that they cake or bridge on the surface of the stone in such a manner as to prevent the perfect filling of all voids and the direct bearing of the roller on the coarse aggregate. It may be required that the screenings be swept in with rattan, or other fibre brooms. (This precaution, however, will be unnecessary if the screenings are applied in sufficient number of light applications so that at no time will there be an excess of screenings at any place on the surface.) The spreading and rolling shall continue until no more screenings will go in dry. No excess of screenings shall be used before applying water.

Spreading Screenings From Trucks. If screenings are applied direct from trucks, the trucks shall be driven, all the time, to the place of spreading, over the filled portion of the road. In no case shall the trucks be driven over loose or unfilled stone, except the short distance necessary where the spreading is being done. The screenings shall never be dumped directly upon the road surface. They may be dumped upon a platform, from which they will be spread by shovels over the surface. Great care must be taken at all times never to permit sufficient screenings to fall at

any one place to bridge over the voids in the coarse stone, or to make a surplus of screenings upon the surface.

When the trucks are being driven upon the partially completed surface, great care must be exercised so as not to disturb the coarse stone. The trucks shall not be of larger capacity than one (1) ton, nor be driven faster than six (6) miles per hour.

The rollers must follow all the time, immediately after the trucks making the thin spread of screenings, so as to thoroughly roll the stone and thus solidify it as described under rolling. The waterbinding shall be kept completed at all times close up to the point of application of the screening, so as to prevent the trucks from disturbing the filled stone. If at any time during the work the coarse stone is disturbed, it shall be promptly again put in place, rerolled and waterbound after any excess of screenings has been removed from the foundation.

Water binding of the base course is not required in many specifications. The specifications given above, omitting the portions applying to the application of water, will serve also for broken stone base course not waterbound.

Still another specification for the construction of broken stone base course quoted from the Tennessee State Highway Specifications is as follows:

Construction Methods

On the prepared subgrade and at the outside edges of the base course being constructed, there shall be set and staked in place guide planks just equal to the thickness of the compacted layer of base being constructed.

After the subgrade has been prepared, checked and approved by the Engineer and after the guide planks have been installed, a layer of No. 2 size crushed stone shall be spread over the subgrade to such a depth that after compaction, it shall have the uniform thickness indicated on the typical cross-section of the plans.

The spreading of the crushed stone shall be accomplished by means of vehicles and previously approved spreading devices, or from dumping boards. In no case shall material be dumped directly on the subgrade in piles or windrows. The depth of the loose stone, unless otherwise directed, shall be gauged by means of wooden blocks, the three (3) minimum dimensions of which shall be just equal to the required depth of loose stone. Before rolling is begun the wooden blocks must be removed and the spaces occupied by them filled with stone of the size and quality specified for this layer.

Loose stone shall not be spread more than five hundred (500) feet in advance of filling and compacting.

After the loose stone has been spread in the manner specified, it shall be compacted by rolling. The roller used to compact the stone shall be a three (3) wheel power driven machine; shall weigh not less than ten (10) tons; and shall be of the flat wheel type, that is, it shall be so constructed, that the surface of the symmetrical rolling wheels are in a straight line, when tested transversely.

The rolling shall begin at the sides and progress towards the center, parallel to the center line of the roadway, uniformly lapping by one-half ($\frac{1}{2}$) the width of the rear wheel, each preceding track, and continuing until the entire surface has been rolled by the rear wheel, and until there is no material disturbance of the stone ahead of the roller.

After this layer has been spread and compacted in the manner outlined, it shall be uniformly covered with a thin layer of screenings and again rolled while dry.

Screenings may be stocked along the roadway without the lines of the pavement, but must not be stocked, or piled, in such a way as to interfere with the drainage of the subgrade, or roadway.

The application of screenings and rolling shall continue until all voids are filled and there is no disturbance of the stone ahead of the roller.

In connection with the application of screenings and rolling, and to facilitate the filling of voids, brooms will be utilized. These brooms shall consist of hand push brooms and also a broom rigidly coupled to the roller. This latter broom shall be at least as long as the full width of the roller, and shall be so attached to the roller that it may be raised when not in use.

After all the voids have been filled, as far as is possible, with screenings, by spreading, rolling and brooming this layer while dry, water shall then be sprinkled on the layer, and the spreading of screenings,

brooming and rolling continued. The process of rolling, spreading of Screenings, brooming, and sprinkling shall be continued until all voids are filled, and a thoroughly compacted waterbound macadam layer, free from waves and irregularities and true to grade and cross-section, is produced.

The sprinkling must be conducted in such a manner, and with such equipment, as is satisfactory to the Engineer.

When rolling shall have been completed on this layer, all excess screenings shall be broomed off the surface, and the surface shall be firm, even, and true to lines, grades and cross-sections, and sufficiently rough to afford a good mechanical bond with the next layer.

Just previous to the completion of this layer, the guide planks shall be removed and the space occupied by them shall be filled with shoulder material and thoroughly tamped into place. The final rolling of this layer shall include as much of the shoulder as is practicable without endangering the work.

After the completion of this layer such hauling as is necessary for the bringing on of materials for the next layer will be permitted.

Teaming of any kind, and for any purpose, over or on any partially or wholly completed layer is prohibited, unless otherwise permitted in writing, by the Engineer.

Should it develop that, during the construction, or after the completion, of the first layer, and during the construction of any of the succeeding layers, the subgrade material has been churned up, or mixed with the crushed stone of the first layer, due to hauling, rolling, travel or any other cause, the Contractor shall immediately, without compensation, entirely remove the defective portions of the construction, and reconstruct the subgrade and each course individually until the defective work has been brought to the same standard of quality and the same status as the adjacent construction.

All material necessary to be removed on account of defective work, shall be discarded, removed from the right-of-way, and replaced with new materials meeting the requirements of these Specifications.

Bituminous Macadam Base Course

In the construction of a bituminous macadam base course the same precautions must be taken as later described under the construction of the bituminous macadam surface, except for certain variations in details of construction. The same size stone will be used in this course as in the top course. After compaction it is given a single penetration of bituminous material, not exceeding $1\frac{1}{2}$ to $1\frac{3}{4}$ gal. per sq. yd. of surface. While the bituminous binder is still warm, a layer of choke stone is applied over the entire surface in just sufficient quantity to fill the surface voids. The surface is then rolled until bonded and compacted thoroughly and any excess of stone is swept off the roadway. The size of choke stone used depends upon the size of stone employed in the base course. This will be discussed later under "Surface Course."

Surface Course

A bituminous macadam surface course varies in thickness from $2\frac{1}{2}$ to 3 inches and is laid on a base course of one of the types previously described. *The keynote of success in the building of a bituminous macadam wearing surface is the strictest attention to the proper performance of every detail of the operation.* Uniformity of surface in compaction and in texture should by all means be sought. Extreme care must be taken that the surface have a uniform ap-

pearance everywhere before the application of bituminous material and that there are no spots where undue crushing of the stone has resulted in a partial closing of the surface voids, thus interfering with the penetration of the bitumen. It is likewise important that the rolling operation be so conducted as to obtain uniformity of compaction and smoothness of surface before applying the bituminous material. *The resistance of a bituminous macadam surface against waving is largely dependent upon the mechanical bond and interlocking effect of the stone and, therefore, it is important that thorough rolling be given to firmly lock the stone together before any bitumen is applied.* The bituminous material largely serves the function of preventing upward displacement of the stone under the action of traffic and to some extent also its adhesive effect aids the mechanical bond. *An excess of bituminous material is one of the known causes of lack of stability and is one of the evils to be guarded against in bituminous macadam construction.*

Sequence of Construction Operations— Bituminous Macadam Surface Course

The bituminous macadam surface course is constructed in two principal ways as follows. For reasons which will be discussed later these methods will be designated in terms of the number of applications of bituminous binder.

Method I—Double Penetration Method

The following steps are carried out in this method:

1. The coarse stone $1\frac{1}{2}$ - $2\frac{1}{2}$ in. or $1\frac{3}{4}$ -3 in. is spread uniformly between headers on the base course to the proper depth. A compacted thickness of $2\frac{1}{2}$ to 3 in. is desirable.
2. Coarse stone is thoroughly rolled and compacted with a 10 to 12 ton roller.
3. Bitumen is applied uniformly with pressure distributor at the rate of $1\frac{3}{4}$ gal. per sq. yd., if $1\frac{1}{2}$ - $2\frac{1}{2}$ in. stone is used; and 2 gal. per sq. yd., if $1\frac{3}{4}$ -3 in. stone is used.
4. Keystone, $\frac{5}{8}$ -1 in.* for $1\frac{1}{2}$ - $2\frac{1}{2}$ in. coarse stone and $\frac{3}{4}$ - $1\frac{1}{4}$ in. for $1\frac{3}{4}$ -3 in. coarse stone, is applied to the amount of one ton per 40 sq. yds. of surface when hard stone is used. This should be reduced when soft stone is employed.
5. Surface is thoroughly rolled to force keystone into surface voids and produce tightly compacted surface.

* (Note: This size is best adapted to asphalt binder. Better results are said to be obtained when a smaller size ($\frac{3}{8}$ - $\frac{1}{2}$ in.) is used with tar binder.)

6. Second application of bituminous binder is given at the rate of $\frac{3}{4}$ gal. per sq. yd. with hard stone and $\frac{1}{2}$ gal. with softer stone cover.
7. Cover stone ($\frac{3}{8}$ - $\frac{5}{8}$ in. or $\frac{3}{8}$ - $\frac{3}{4}$ in.) in size to the amount of one ton for 55 to 70 sq. yds., the latter figure for cover applied in late fall. The larger size is for use with larger size coarse stone.

The above method is particularly applicable to bituminous macadam constructed with the hardest varieties of stone.

Method II—Triple Penetration Method

The following is usually referred to as a double seal coat method. It is most used with the softer varieties of stone.

1. Spread stone, $2\frac{1}{2}$ - $3\frac{1}{2}$ in. or $2\frac{1}{2}$ -4 in. in size, uniformly to proper depth between header boards and using spreading devices.
2. Roll and thoroughly compact stone with 10 to 12 ton roller. Over-rolling which crushes stone should be avoided and shattered stone spots should be replaced and recompact. A compacted thickness of 3 inches is desirable.
3. Apply bitumen with pressure distributor at the rate of 1.5 gal. per sq. yd.
4. Apply $\frac{3}{4}$ - $1\frac{1}{2}$ in. coarse covering or choke stone at the rate of 1 cu. yd. to 250 sq. yd. of surface (1 ton per 194 sq. yd.).
5. Roll before bituminous material hardens and continue rolling until solid compact mass results.
6. A small amount of fine cover material ($\frac{1}{2}$ - $\frac{7}{8}$ in.) should be swept over the surface to loosely fill surface voids.
7. Apply second application of bituminous material at the rate of 0.5 gal. per sq. yd.
8. Broadcast just sufficient fine cover over the surface to prevent roller wheels from sticking.
9. Roll surface to thoroughly compact it. Roller should be used on at least 5 days when the bitumen is soft. Additional fine cover should be applied sparingly as required during the rolling. Total amount should not exceed 1 cu. yd. to 240 sq. yds. of surface (1 ton for 200 sq. yd.).
10. Any voids left in top should be filled by brooming fine covering material over surface and surplus should be swept off.
11. Apply third treatment of bituminous material at the rate of $\frac{1}{3}$ gal. per sq. yd.
12. Cover with fine cover material at the rate of one cu. yd. to 120 sq. yd. of surface (one ton per 100 sq. yd.).

13. If heavy bituminous material has been used in the third application, the surface should be rolled after the application of fine cover.

The strictest attention to every detail of construction is essential to the success of a bituminous macadam surface course. *This point is again emphasized for it is too frequently overlooked and greatly inferior inspection is too often the rule.*

Details of Construction of Surface Course Quality of Stone

The quality of stone in the top course is governed by several considerations. In the first place, the top course of stone is subjected directly to the wear of traffic and hence must be sufficiently resistant to endure under that kind of service. Especially is this so after the surface assumes a mosaic appearance, as it will when the right amount of bituminous binder for the greatest stability has been used. As it is highly essential that the compacted stone present a uniform appearance before the application of the bituminous binder, the stone should be of fairly uniform size and the voids should be of uniform distribution and size. If the stone is so soft that it will crush easily under the roller, this desirable condition of uniformity will not obtain and there will be pockets of shattered material which will prevent the proper penetration of the bituminous binder and future disintegration will occur at these spots.

The quality of the stone can not well be considered without likewise considering its size. Hard, tough stone is used entirely in those sections of the country where it abounds and in other sections limestone or other comparatively soft stone is used exclusively. Good results are obtained with both when the proper precautions are taken. There is a limit to the softness of the stone used in the wearing course and, preferably, it should have a percentage of wear in the Deval Abrasion Test of not more than 6.0. If the percentage of wear exceeds 4.0 the size of stone should extend from $2\frac{1}{2}$ to $3\frac{1}{2}$ or 4 inches. It may be $1\frac{1}{2}$ to $2\frac{1}{2}$ inches for harder stone than this. Uniformity of size is a great essential in the stone in the body of the surface. There must be no chance for the collection of pockets of fine material. It is claimed by some authorities that the maximum size of stone should not be greater than the compacted thickness of the top course. But on the other hand 4 to $4\frac{1}{2}$ inches maximum size is used successfully in a 3 inch compacted layer where limestone is employed. Stone passing a 4-inch ring invariably has at least one diameter which is considerably less than

4 inches and the stone tends to assume a flat-lying position under the action of the roller.



Fig. 5.—A strike board should be used on the base and the surface course to obtain the proper cross-section

The stone should also have a fracture such that it will not have flat and needle-like pieces which will either tilt or break under traffic because they generally lie with their long dimension in a horizontal direction. It is also important that the stone be clean and free from a film of dust which will prevent proper adhesion of the bituminous material. Some stones are also of such a nature that the bitumen does not adhere to them well.

The stone ultimately carries the traffic when the right amount of bitumen has been employed and the surface of the road presents a partially mosaic appearance. It is felt that the use of more bitumen, in an effort to provide a blanket or seal course to carry the traffic and resist its wear, is quite certain to lead to a corrugated surface which by all means should be avoided. Then, too, in warm weather the use of excessive bitumen in the so-called seal coat will necessitate the spreading of additional screenings and thus additional maintenance expense is necessary. The reason for avoiding the term "seal-coat" in referring to the last coats of bitumen applied should now be apparent.

Spreading the Coarse Stone

The coarse stone for the surface course is spread as uniformly as possible, using the precautions already described under "Base Course." The stone is spread between headers of the proper thickness laid on and spiked to the base course and backed up with shoulder material. The loose stone, as a rule, should be laid to a depth which is 50 per cent in excess of the compressed thickness desired. After spreading, if a wavy, uneven or non-homogenous surface results, it should be harrowed with a heavy spike-toothed harrow. The stone should also be raked into position with long-

tooth stone rakes and hand-placed so that when tested with a strike board resting on the side forms (see Fig. 5), the surface will be true to cross-section, free from waves, homogeneous in appearance and without pockets of fine or unduly coarse material. A view showing a typical appearance of coarse stone of large size ($2\frac{1}{2}$ - $4\frac{1}{2}$ in.) before rolling is shown in Fig. 6. It is far easier to correct large inaccuracies in the surface before rolling, while the stone is loose, than after it is compacted.

Rolling the Coarse Stone

After the stone is spread and brought uniformly to proper cross-section, the side forms are removed and the space which they formerly occupied is filled with earth, rammed into place. It is essential that sufficient shoulder material be used to back up the forms in a substantial manner so that when it is compressed under the weight of the roller, the stone along the sides will be adequately supported. The riding qualities of a bituminous macadam road may be ruined along the sides over a strip several feet in width if the stone is not properly backed up with shoulder material during the rolling operation.

The roller used should be of the three wheel type, weighing not less than 10 tons and should apply a pressure on the rear wheels of not less than 400 pounds per lineal inch. Rolling is started at the sides of the road and the rear wheel should over-lap the shoulder about half its width. The roller should proceed slowly and should not be started or stopped with a jerky motion which tends to displace the stone. Rolling faster than 60 feet per minute tends to create waves and should not be allowed. The path of each successive trip of the roller should be closer to the center of



Fig. 6.— $2\frac{1}{2}$ - $4\frac{1}{2}$ in. stone in base course before rolling. The side forms will be withdrawn and the resulting space tamped with earth before rolling.

the road, the wheels, however, overlapping their previous path. Stops should not be made in the same

spot and when an additional section is ready for rolling, the roller should reverse its direction over the

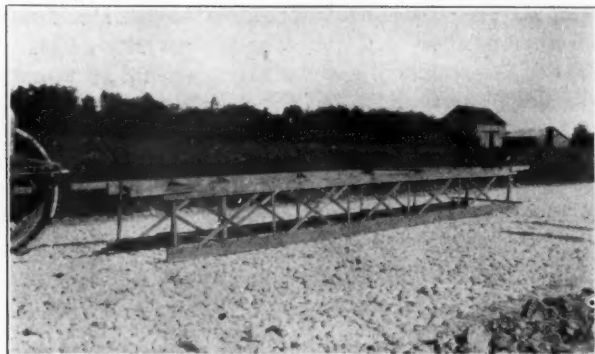


Fig. 7.—Longitudinal template for testing the smoothness of the base and the surface course.

previously rolled stone. When one side of the road is rolled, the roller should start at the opposite edge and work toward the center. The rolled sides thus develop lateral resistance against displacement during the rolling of the central portion and greater compaction of the surface results and a truer cross-section is also maintained.

After the first pass of the roller any necessary patching should be made to bring the surface up to the required smoothness. An 18-foot to 20-foot straight-edge should be used to test the surface at this stage. (See Fig. 7.) If low spots appear, the surface should be loosened and additional stone added and rolled in. Only by taking such precautions can a desirably smooth riding surface be obtained. The finished surface should be required to have no depressions greater than $\frac{3}{8}$ inches in 18 feet and this will necessitate constant care in each operation.

Extent of Rolling Coarse Stone

The rolling should continue until the stone is firmly compacted and there is no movement under the roller. However, when the softer stone is used, the surface must be watched to see that excessive rolling is not given which will so fracture the stone that the surface voids will be partially closed thus preventing proper penetration of the bitumen. The stability of a bituminous macadam surface course depends largely on the mechanical bond and interlocking effect of the stone; hence, it is vital that the stone layer be compacted before any bitumen whatever is applied. In Figs. 5, 9, and 10 are shown some defects in the surface course after rolling and in Fig. 11, a suitably uniform surface is illustrated.

Bituminous Binder Function of the Binder

—The bituminous binder serves several purposes. In the first place it is adhesive and hence aids in holding the stone in position, particularly against upward displacement under the action of traffic. Secondly, it is a water-proofing material and hence prevents an undue amount of free water from reaching and softening the subgrade. Obviously, both of these functions will be served most effectively the more uniformly and more thoroughly the stones are coated.

Applying the Bituminous Binder

When the binder is applied, the stone should be dry and the atmosphere should be at a temperature above 45°F., and preferably above 65°F. Moreover, there should not have been any freezing weather during the preceding night. The surface should be free of sticks, twigs or leaves which may have blown from adjacent trees. A pressure distributor should be used and a pressure of at least 25 pounds per square inch should be maintained at all times. The distributor should first be examined and tested to see that all nozzles are clean and the mechanism working properly. By all means a thermometer should be provided to determine the temperature of the bitumen. When tar is used the temperature should be maintained at 225°F. to 275°F. and for asphalt the temperature should be from 275°F. to 350°F. If too cool, the bitumen will not penetrate properly and will cause bleeding in hot weather. If over-heated for an appreciable length of time, brittleness of the binder will be the result.

In applying the binder, uniformity is all important and experienced distributor men, only, should be employed. A stake is set at the point where the tank



Fig. 8.—Close-up of wearing course showing defective spot due to crushing of soft stone under the roller. Unless this defect is corrected the bituminous binder will not penetrate properly.

should be empty if the binder has been applied at the proper rate and an experienced driver should be able

to empty his tank within 10 or 20 feet from this stake. On an 18 foot road it is well to apply binder first over



Fig. 9.—Long slivery pieces are undesirable in the surface course. They should be broken.

a width of 10 feet, preferably on the left side of the road, for the driver sitting on the left is then able to use the side of the road as a guide. There then remains a strip 8 feet wide to be penetrated. Subsequently, when a later coat of binder or seal coat is applied the 10 foot application should lie over the 8 foot strip. In this way a strip near the center of the road having excessive bitumen is avoided. Should spots be missed in the first application, these, by all means, should be penetrated before going on with the subsequent operation. If dependence is placed on the subsequent coat or coats of bitumen to penetrate these spots, they are almost sure to ravel in time, for they will contain insufficient bitumen. Should pools of bitumen form, this is an indication of faulty penetration and such spots should immediately be loosened up with a pick to allow the hot bitumen to drain into the surface course. Corrugations will form later if this is not done.

Amount of Binder in First Application

Ordinarily, it is generally planned to apply from 1.5 to 1.75 gallons of bitumen, when the depth of the surface course is $2\frac{1}{2}$ inches. The size of stone employed, the thickness of surface course, and, finally, the type of construction, whether a triple penetration or double penetration road, will influence the amount to some extent.

However, when the stone is $1\frac{1}{2}$ - $2\frac{1}{2}$ inches in size and double penetration is to be given, 1.5 to 1.75 gallons per sq. yd. is about right for the first application. When a triple application is to be used with $2\frac{1}{2}$ - $3\frac{1}{2}$ or $2\frac{1}{2}$ -4 in. stone, 1.5 gallons per sq. yd. is recommended.

Characteristics of Bituminous Binder

The bituminous binder may consist of either tar or asphalt. Both are successfully used in different sec-

tions of the country, although personal preference for one over the other is shown by individual engineers. The characteristics should vary, depending upon the temperatures to be encountered, the kind of stone used, whether hard or soft, and upon the severity of traffic. It is to be presumed, however, that when a bituminous macadam surfacing is to be constructed, the traffic is at least of a moderate intensity or heavier.

The specifications for tars and asphalts shown in Tables I and II are compiled from those recently issued by the Federal Specifications Board for use in bituminous macadam construction in various parts of the United States. Material suitable for the northern United States will likewise apply to Canada.

Keystone or Choke Stone

Immediately after the first coat of bitumen has been applied, keystone is broadcast over the surface from stock piles *which have been previously placed along the sides of the road before the coarse stone has been spread*. If a 10-foot strip has been penetrated with bitumen, only a 9-foot width should be filled with keystone, leaving a strip one foot in width down the center, unfilled. This will prevent a ridge from forming in the center of the road due to the use of excessive keystone.

Function of Keystone

The purpose of the keystone is to fill the voids between the coarse stone and to wedge them tightly into place. It is not at all the idea that the keystone shall form an extra layer on top of the coarse stone. To properly serve its function the keystone must be of the right size to wedge into the voids in the coarse stone and must be distributed in just the right amount.

Proper Size of Keystone

It should be understood that the most important

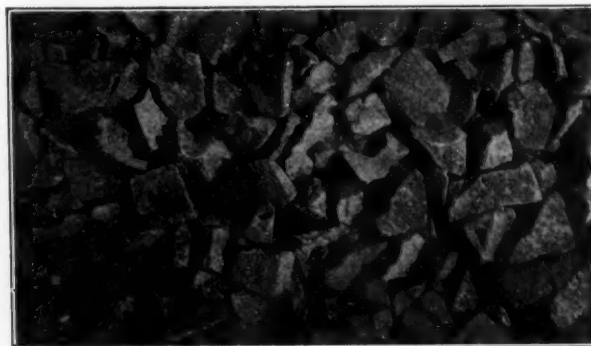


Fig. 10.—Cinders dropped from the roller should be removed before applying the bituminous binder.

function of the keystone is to wedge the coarse stone into position and thus keep it from corrugating under

traffic. When the coarse stone is hard and of a size $1\frac{1}{2}$ - $2\frac{1}{2}$ inches, it is recommended that the keystone extend from $\frac{5}{8}$ to 1 inch in diameter, as determined by circular opening laboratory screens. When $2\frac{1}{2}$ - $3\frac{1}{2}$ in. or $2\frac{1}{2}$ -4 in. soft limestone is used, good results are obtained with keystone, $\frac{3}{4}$ - $1\frac{1}{2}$ inches in diameter. It has been claimed, however, that when tar is used better results are obtained with smaller keystone of $\frac{3}{8}$ to $\frac{1}{2}$ in. average diameter. If the keystone is much larger than the maximum above stated, it is difficult to force it into the surface voids without undue crushing. All keystone should be clean and free from dust.

Amount of Keystone

The amount of keystone should be regulated so that just enough will be applied to fill the voids in the coarse stone with no excess on the surface. If too much keystone is applied, the excess will crush under the roller and form a crust on the surface which will interfere with the adhesion of the next application of bitumen. When the method of construction involves only two penetrations of bituminous material, more keystone should be used than when three penetrations are employed. Roughly, one ton of hard stone per 40 sq. yds. is recommended in the first method and one ton per 194 sq. yds. in the second method, when softer and larger stone is used. When three penetrations of bituminous binder are given, the surface voids must not be so completely filled with keystone as when only two penetrations are used. If, in the first method

(double penetration method) the stone is softer than the hardest of trap rocks the amount of keystone



Fig. 11.—Uniform appearance of surface course necessary for uniform penetration of bituminous binder.

should be reduced because there will be some filling of the voids due to crushing of the coarse rock.

Rolling the Keystone

Immediately after the application of the keystone the road should be very thoroughly rolled before the bituminous material hardens to such an extent as to prevent the keystone from being thoroughly incorporated with it. Necessarily the bitumen will harden faster in cool weather, thus requiring an early completion of the rolling, whereas, in hot weather the rolling should be continued longer, or perhaps delayed. As the rolling progresses it may be found that more keystone should be added and broomed over the sur-

TABLE I—SPECIFICATION FOR REFINED TAR FOR BITUMINOUS MACADAM CONSTRUCTION
(Based on Federal Specification Board Specification No. 282)

Intended Use	Northern United States Light or Moderate Traffic		Middle or Northern United States Heavy Traffic		Southern United States	
	Refined Water-Gas Tar	Refined Coal Tar	Refined Water-Gas Tar	Refined Coal Tar	Refined Water-Gas Tar	Refined Coal Tar
Requirement	TP-1-25	TP-2-25	TP-3-25	TP-4-25	TP-5-25	TP-6-25
1. Specific gravity $25^{\circ}/25^{\circ}\text{C.}$ ($77^{\circ}/77^{\circ}\text{F.}$)	1.150 to 1.200	1.200 to 1.260	1.150 to 1.200	1.200 to 1.260	1.150 to 1.200	1.200 to 1.260
2. Float test at 50°C. (122°F.)	100 to 160 sec.	100 to 160 sec.	130 to 190 sec.	130 to 190 sec.	160 to 220 sec.	160 to 220 sec.
3. Total distillate by weight To 170°C. (338°F.) not more than To 270°C. (518°F.) not more than To 300°C. (572°F.) not more than (a) Softening point of residue, not more than	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
	65°C. (149°F.)	65°C. (149°F.)	65°C. (149°F.)	65°C. (149°F.)	65°C. (149°F.)	65°C. (149°F.)
4. Bitumen (soluble in carbon disulphide)	not less than 95.0%	80.0 to 95.0%	not less than 95.0%	80.0 to 95.0%	not less than 95.0%	80.0 to 95.0%

TABLE II—SPECIFICATION FOR ASPHALT IN BITUMINOUS MACADAM CONSTRUCTION
(Based on Federal Specifications Board Specification No. 276a)

Intended Use	Northern United States Comparatively Light Traffic		Middle United States or Northern United States Comparatively Heavy Traffic		Southern United States	
	Petroleum Asphalt	Fluxed Native Asphalt	Petroleum Asphalt	Fluxed Native Asphalt	Petroleum Asphalt	Fluxed Native Asphalt
Designation	AP-1-25	AB-1-25	AP-2-25	AB-2-25	AP-3-25	AB-3-25
1. Specific gravity 25°/25°C. (77°/77°F.)	not less than 1.000	1.025 to 1.050	not less than 1.000	1.040 to 1.060	not less than 1.000	1.050 to 1.070
2. Flash point, not less than	175°C. (347°F.)	175°C. (347°F.)	175°C. (347°F.)	175°C. (347°F.)	175°C. (347°F.)	175°C. (347°F.)
3. Softening point	35°C. to 55°C. (95°F. to 131°F.)	35°C. to 45°C. (95°F. to 113°F.)	35°C. to 55°C. (95°F. to 131°F.)	40°C. to 50°C. (104°F. to 122°F.)	40°C. to 60°C. (104°F. to 140°F.)	40°C. to 50°C. (104°F. to 122°F.)
4. Penetration at 25°C. (77°F.), 100g., 5 sec.	120 to 150	120 to 150	100 to 120	100 to 120	85 to 100	85 to 100
5. Ductility at 25°C. (77°F.) not less than	....	....	....	....	....	....
6. Loss at 163°C. (325°F.) 5 hrs. not more than	1.0%	3.0%	1.0%	3.0%	1.0%	3.0%
(a) Penetration of residue at 25°C. (77°F.) 100 g 5 sec., as compared to penetration before heating, not less than	60.0%	50.0%	60.0%	50.0%	60.0%	50.0%
7. Bitumen (soluble in carbon disulphide), not less than	99.5%	95.0%	99.5%	95.0%	99.5%	95.0%
(a) Organic matter insoluble not more than	0.2%	....	0.2%	....	0.2%	....
(b) Inorganic matter insoluble	....	1.5% to 2.5%	....	1.5% to 3.0%	....	1.5% to 3.0%

face to fill the voids. The idea should be borne in mind, however, that an excess should not be used, for the roller should bear on the coarse stone and should not be supported by the keystone. Care must be taken with the rolling at this stage. The roller must not be permitted to stand on the surface before the completion of the rolling and the surface must be kept clean and traffic should not be permitted on it. If, during the progress of the rolling deformations of the surfaces develop, these should be corrected by rolling into the depressions, bituminous coated stone of a suitable size. At this stage of the work, *thorough rolling must be given* until the surfacing is compacted to a solid, smooth layer. After rolling is completed, the surface should be broomed clean of all fine stone not firmly held by the bitumen. It is then ready for the application of the second coat of bitumen.

Second Penetration (Double Penetration Method)

If the pavement is constructed by the double pene-

tration method (one penetration and one seal coat) the second coat of bitumen is the final coat. It is applied in the same way as the first coat, but the amount is decreased to $\frac{1}{2}$ or $\frac{3}{4}$ gallons per sq. yd. It is not the idea that this coat shall form a mat or carpet over the surface. It should not be applied in such excessive quantities that pools will remain, but it should be absorbed in large part by the voids in the surface course.

If a 10-foot strip of bitumen is applied on the left side of the road in the first application, it will be well to apply only an 8-foot strip in the second application so that the edge of the two applications will not fall in the same line. This will make for uniformity in quantity of bitumen in the center of the road.

Building paper should be spread and weighted down on the road surface and the distributor should be opened before it reaches the desired point of application; and the excess bitumen is caught on the paper. In this way the distributor may be given a flying start

and will be running at the proper speed at the beginning of the strip to be treated.

Cover Stone (Double Penetration Method)

The final application of bitumen is covered with stone of a size which will wedge into the voids remaining in the surface course. When hard stone $1\frac{1}{2}$ - $2\frac{1}{2}$ in. has been employed with $\frac{5}{8}$ -1 in. keystone, the cover stone should be $\frac{3}{8}$ - $\frac{5}{8}$ in. With $1\frac{3}{4}$ -3 in. hard stone, $\frac{3}{4}$ - $1\frac{1}{4}$ in. keystone, $\frac{3}{8}$ - $\frac{3}{4}$ in. cover stone is of about the right size. The cover stone should be broadcast with a sweeping motion of the shovel so as to secure as uniform a distribution as possible. An excess of cover stone, more than will bind with the bitumen, is to be avoided. It is well to apply the cover sparingly at first and during its application the surface is rolled. As the need for more cover material develops, it is applied in the desired spots until the entire surface is uniformly covered with little, if any, more cover than will combine with the bitumen.

Second Penetration (Triple Penetration Method)

The second penetration coat in this method is not the final course as in the Double Penetration Method of Bituminous Macadam Construction. The same method of applying the bitumen is employed, however, but the amount is only 0.5 gal. per sq. yd. The same grade of bitumen is used as in the first coat. Immediately following the application of bitumen, fine cover material, $\frac{1}{2}$ - $\frac{7}{8}$ in. is used, if the coarse stone is $1\frac{1}{2}$ -4 in. and the choke stone is $\frac{3}{4}$ - $1\frac{1}{2}$ inches in size. This combination of sizes is about right for limestone. Just enough cover is employed to prevent the roller from sticking. The road should be rolled until it is firm and thoroughly compacted. During the rolling, additional cover should be spread in those spots where it is needed. *By no means, however, must the cover form a mat on the surface but should merely fill the surface voids. The rolling must be thorough after the cover has been applied and rolling should be given every day for 5 or 6 days at a time of the day when the road is sufficiently warm so that it will be compacted by the roller.*

Third Penetration (Triple Penetration Method)

Before the third coat of bitumen is applied just enough fine stone $\frac{1}{2}$ - $\frac{7}{8}$ inches in size is broomed over the surface to fill the surface voids. A light penetration of 1.3 gallon of bitumen is then given. The bituminous material may be either refined tar, road oil for hot application or liquid asphalt for which the following specifications are typical.

Specifications of Bituminous Material for Third Application of Surface Treatment

Tars (For Surface Treatment)

Tars TM and TH shall meet the following requirements:

	TM	TH
1. It shall be homogeneous		and free from water
2. Specific gravity 25°/25°C...	1.13 to 1.20	1.18 to 1.26
3. Specific viscosity at 40°C....	25 to 40	
4. Float test at 32°C.....		120 to 180 sec.
5. Total distillate by weight:		
Water not more than....	2.0%	
To 170°C., not more than..	5.0%	1%
To 270°C., not more than..		18%
To 300°C., not more than..	33.0%	24%
(a) Softening point (Ball and Ring) of residue, not more than.....	65°C. *	70°C.
(b) Specific gravity of distillate, not less than	1.00	25°/25°C.—1.03
6. Total bitumen (soluble in carbon disulphide).....	88 to 97%	83 to 95%
(a) Inorganic matter insoluble, not more than	0.5%	not over 0.5%

Tar TM shall be at a temperature of 125° to 150°F. and tar TH at between 150° and 200°F. when applied to the road surface.

Asphalt OH-1 (For Surface Treatment)

This asphalt shall meet the following requirements:

1. It shall be homogeneous, free from water, and shall not foam when heated to 275°F.	
2. Specific gravity 25°/25°C., not less than....	0.980
3. Flash point, not less than.....	90°C.
4. Specific viscosity at 100°C., not less than....	25
5. Penetration at 25°C., 50g., 5 sec., not less than	350
6. Loss at 163°C. 5 hours (20g. sample) not more than	5%
7. Total bitumen (soluble in carbon disulphide) not less than.....	99.0%
8. Per cent of total bitumen insoluble in 86°B. naphtha	12% to 25%

The asphalt OH-1 shall be at a temperature between 225° and 275°F. when applied to the road surface

Liquid Asphalts (For Surface Treatment)

Liquid asphalt shall meet one of the following requirements:

	Liquid Asphalt AC For General Surface Treatment	Liquid Asphalt CB For Heavy Surface Treatment
1. It shall be homogeneous in character and free from water.		
2. Flash point (open cup) not less than	90°F.	80°F.
3. Specific viscosity at 122°F....	20 to 100	100 to 200
4. Separation of asphalt base from Distillate Flux		
(a) Distillate by volume		
Per cent off at 437°F. not less than.....	10	5
Per cent off at 600°F. not less than.....	20	15
Per cent off at 680°F. not more than.....	35	30
(b) Characteristic of residue from distillate to 680°F. Penetration at 77°F., 100g., 5 sec.....	70 to 110	60 to 110
Per cent bitumen, soluble in carbon disulphide, not less than..	99.0	99.0
Ductility at 77°F. not less than	100	100

(Continued on page 20)

The Federal Trade Commission'

BY HON. W. E. HUMPHREY
Chairman, Federal Trade Commission

Editor's Note: The attitude of the Federal Trade Commission towards American business and trade association activities is of vital interest to every business man of the country.

During the last few years there has been evidenced a remarkable and most beneficial change as regards the procedure followed by the Commission in dealing with supposed violations of the anti-trust laws. Relative to the former practice of the Commission, Commissioner Humphrey says:

"I think the time has come to stop scourging American business first and finding out afterwards whether it be guilty or not," and further that

"Whatever changes political fortune may in the future bring in the personnel of the Commission, the system of condemning before trial or finding guilty without evidence, will never again be used by the Federal Trade Commission."

The following address by Commissioner Humphrey clearly and emphatically defines the function of the Commission and the procedure under which it proposes to operate, and as such should be decidedly interesting and illuminating to the business men of our industry.

THREE years ago I had the honor of speaking before this great organization. What I told you then was largely of prophecy, and of promise. Today, I want to tell you something of accomplishment and of things done.

But, first, in view of the oft repeated statement that under the present policies, the Commission has departed from its original purpose, it might be well to see what gave it birth:

Prior to the Federal Trade Commission statute, the only anti-trust act was the Sherman law. The full meaning of that act no one knew then and no one knows today. As to its meaning, lawyers differed, judges disagreed and courts were in conflict. It frequently happened after they had received the best legal advice and made every effort to know what the law was, business concerns were prosecuted and punished, or imprisoned, or both, by a decision rendered by a divided court.

The injustice of this law, the harshness and wrong of punishment administered under such circumstances, appealed to the public conscience. The effect of this law upon the business of the country was so destructive and disastrous that public opinion demanded a remedy for a condition that was intolerable. The result was the creation of the Federal Trade Commission.

The primal purpose of the Federal Trade Commission is to determine before prosecution or punishment the unfairness of any practice and to issue an order to cease and desist from such practice. I want to emphasize the fact that the Federal Trade Commission has no power to punish. It was never intended by the Congress that it should have such power. Punishment is left entirely to the courts. The courts cannot punish until they enter their own decree and then punish for violation of that decree, and not for any violation of the Federal Trade Commission Act. In other words, the Federal Trade Commission can only give warning to the violator, and if he then stops his unlawful practice, he cannot be punished for what he has already done, by either the Commission or the court.

Under the former practice, when a complaint was received the Commission directed an investigation. Sometimes such an investigation was complete. Usually it was superficial—and always it was ex-parte. Upon such a report, if they believed the facts warranted, the Commission issued its complaint. Simultaneously with the issuance of a complaint, it gave to the public a statement as to the facts. Coming with official sanction, the public generally accepted such statement as a finding that the facts alleged were true. Coming with apparent official sanction, these statements were often given wide publicity—especially if the allegations were sensational or the parties accused were prominent, or where the political effect might be great. It frequently happened that the accused knew nothing whatever of the matter until he was advertised in the press of the country—sometimes in screaming headlines, on front pages, as a violator of his country's laws. By its own admission, made by its own record, the accusations in more than one-half these cases were afterwards found to be untrue, and the Commission voluntarily dismissed the complaint; and in one-half of the cases where the Commission thought they were right, that were passed upon by the court, the court found that the Commission was wrong.

But the dismissal of these actions were sometimes delayed months, and even years, and when the dismissal finally came it attracted little attention; it was not news.

By this procedure the citizen was often unjustly accused, his credit injured, business destroyed, repu-

'Address presented before the Chamber of Commerce of the United States at its 16th Annual Meeting in Washington, D. C., on May 10, 1928.

tation blackened, investments wiped out, men and women forced into unwilling idleness, the public mind unjustly poisoned; and for all these monstrous wrongs there was no redress.

No other governmental agency ever had a practice so tyrannical and so repugnant to every sense of justice. It is not strange that business then looked upon the Federal Trade Commission with apprehension and resentment. It is not strange that this great body I am addressing gave public expression to this feeling.

Because the courts "will not correctly interpret the law" is no longer given as an excuse for not dismissing a case and for continuing to expound its awfulness until it is stale and enfeebled with age.

We are trying today to exercise the authority given us by Congress as interpreted by the courts.

As the law is, we accept it. What it should be we leave to Congress.

The Commission today is neither legislating nor reforming.

Today we do not devote our chief energies to socialistic literary efforts to impress the public that fraudulent practices in business are almost universal. We suppress the practices and let the result furnish the publicity.

We transact business today through the powers of the Commission and not through the columns of the newspapers.

We no longer accept mere accusation as "confirmation strong as proofs of holy writ."

As I have examined the record of the Commission for the years before I became a member, frequently my mind has gone back down the centuries to a scene enacted in the streets of Jerusalem, one of the outstanding events in the record of the race, when the mob cried out for the death of Paul, the greatest of the Apostles. To satisfy this cry the Chief Captain, not knowing whether he was guilty or innocent, or even what the charge might be against him, ordered that he be scourged. They seized and bound him. Then Paul asked them the question that has lived through the ages—"Is it lawful to scourge a man, a Roman citizen and uncondemned?" When the centurian heard this question, he told the Chief Captain and warned him of the consequences of scourging a Roman citizen without trial. Immediately the Chief Captain ordered the Apostle unbound and set free. He knew the danger of punishing a Roman citizen without a hearing.

We are told that in that elder day to be a Roman was greater than to be a king. In this day, certainly it is greater to be an American than it was in that elder

day to be a Roman. Should we show less consideration to the American citizen than was shown to the Roman citizen? Personally I do not believe that we should today, at the cry of the mob, the Bolshevik, the reformer and the fool, treat the American citizen engaged in business as only the barbarian was treated nearly two thousand years ago. I think the time has come to stop scourging American business first and finding out afterwards whether it be guilty or innocent.

Whatever changes political fortune may in the future bring in the personnel of the Commission, the system of condemning before trial or finding guilty without evidence, will never again be used by the Federal Trade Commission.

Stipulations

Today, when an application for complaint is made, we send out our investigators. If their report shows a prima facie case, we then give the accused an opportunity to be heard before we issue a complaint, and accuse him and advertise him as guilty of violating the law. We have heard the accusations against him—usually from his competitor. Why should we not give him an opportunity to be heard before proceeding further—if he so desires? After we have given him a hearing, if we are satisfied that there is no foundation for the accusations, the case is dismissed. If we are satisfied that he has been guilty of some unfair practice—if he so desires, we give him an opportunity to settle the case by agreement and stipulation; and if he is willing to sign a statement to the effect that he will forever cease and desist from such practices, and that if he fails to keep such agreement the written stipulation made by him may be used against him, we accept such stipulation and dismiss the case.

By such stipulation, we accomplish everything and much more than we could possibly accomplish by extended litigation. Remember, as I have already said, the Commission has no power to punish—we can only order him to cease and desist from unfair practices; and if he does this voluntarily thereby accomplishing everything that could be accomplished, and thereby giving to the public more protection than it would possibly receive at the end of any litigation, how can any citizen object to such procedure?

The only exception to this rule of stipulation is where the business or the record of the accused is such that the Commission has reason to believe that such stipulation would not be entered into in good faith and honestly kept, and that such stipulation would only cause delay. Under such circumstances, the Commission feels justified in proceeding at once.

Stipulation is in accordance with the underlying principles of our system of jurisprudence. It is everywhere upheld and endorsed by the courts. Every inducement is held out to encourage this principle. It is especially and specifically encouraged in anti-trust prosecutions. Of all the tribunals of the Government the one that should most encourage settlement by stipulation is the Federal Trade Commission. We are supposed to be as fair in the treatment of the citizen as we try to make the citizen be in his treatment of the public. It is unfair and it is dishonest to say that the anti-trust laws of the country are always knowingly violated. It is absolutely dishonest to say that when men violate the anti-trust laws today their purpose is always as reprehensible and that it is done as knowingly as when men violate laws that have been recognized for ages by common consent without statutes.

It is absolutely dishonest to claim that there is a clear and distinct line between what is and what is not unlawful under the anti-trust acts. Only within the last few months four cases of very great importance have been decided by the Supreme Court of the United States in which the Justices were divided four to five upon the proposition as to whether certain facts constituted a violation of the anti-trust laws. Indeed, it rarely happens that the decisions of this Court are unanimous in an anti-trust case. If this great Court, the greatest that the world has ever known—with men whose integrity is above suspicion, men of great ability, who have devoted their lives to the study of these questions; if these men cannot always agree upon what facts constitute a violation of the anti-trust laws, how can any sane and honest man say that a business man must always know with certainty when he is violating the anti-trust laws.

Crooked Business

I trust that no one will think from anything that I have said or may say that I believe that there is no dishonest business in this country. For there is. While the percentage of business that is dishonest is far less than the agitator and the professional reformer would have us believe, in the aggregate it is far greater than it should be.

It is true that some of the anti-trust acts are violated unintentionally, but there is now less reason for such violations than there was a few years ago. Recent decisions, and particularly by the Supreme Court of the United States, have done much to make plain the lawful path. Most anti-trust law violations today are premeditated and deliberate, and committed in the same spirit as are other crimes for financial gain.

Crooked business is not measured by size. It is true that so-called big business is under closer scrutiny by the Commission—and it should be—than small concerns, because of its greater capacity to affect the public interest. I am constrained to believe that the business of this country, and particularly big business, is more and more forced to the conclusion that honesty is not only the best policy, but that it pays the highest dividends. I feel that there has been a tremendous improvement in the conduct of the business of the country during the last few years, but the time has not come, and I regret to say that it seems far off, when the strong arm of the Government will not be needed to protect the public from greed, monopoly, fraud, and unfair practices.

Trade Practice Conferences

The Trade Practice Conference has been developed and its use is constantly increasing. The representatives of an industry are invited to a conference, called by the Commission and presided over by a member of that Board. This conference is an invitation and an opportunity for the industry to clean its own house, to adopt its own rules of ethics and trade, to achieve decency rather than have decency thrust upon it. These conferences frequently adopt rules in regard to ethics and in regard to economic questions beyond the requirements of the law and beyond the power of the Commission to enforce, but they are observed by the industry by common consent. Those rules that it believes abolish unlawful practices, the Commission approves, and will thereafter attempt to enforce. To rules of ethics and on economic questions the Commission frequently gives the weight of its unofficial endorsement. Beyond this the Commission cannot go.

The benefit of these conferences to the public and to the business of the country has been far beyond the most optimistic hopes of the Commission. I know of no other Government procedure that has done so much to encourage and protect honest business and to protect the public by the elimination of fraudulent and unfair practices.

We had many complaints against the great correspondence school system. This is a gigantic business, doing great good and containing much of evil. There are over three hundred institutions of this character. There are over two million scholars enrolled in these schools, paying more than seventy-five million dollars annually in tuition. Of this vast sum, so paid, thirty-five million dollars was obtained by misrepresentation and fraud. The Commission had issued about two hundred complaints against these schools. It looked

like a hopeless and endless task to end this gigantic fraud. But with the help of many of the honest schools and with the help of public spirited organizations and citizens, we succeeded in bringing about a Trade Practice Conference. A code was voluntarily adopted that condemned all unfair practices. Recently over ninety cases that had previously been brought have been satisfactorily settled. This code is today observed by substantially the entire industry and fraudulent and unfair practices have practically been wiped out.

It would have taken years to have accomplished such results through the courts, even if it could have been accomplished at all.

The correspondence school is typical of the workings of the Trade Practice Conference. All told, we have had more than thirty of these conferences in as many different industries. If the Federal Trade Commission had done nothing else for the last three years beyond what has been accomplished in the correspondence school industry, I think it would have amply justified its existence.

The furniture industry held a conference. Nine hundred and fifty concerns, representing more than 80 per cent of the industry, signed the code there adopted. Fraud in furniture has been largely eliminated. No longer is gum sold for walnut, or birch for mahogany. Who can estimate the benefit of this conference to the public, when you remember that last year five hundred and sixty-one million dollars worth of furniture went into the homes of this country.

The manufacturers of artificial silk, realizing the virtue of their own product, desired to sell it on its own merits alone. They held a conference and adopted the word "Rayon." Before this their product was largely sold as "silk." Regardless of whether it was better or poorer than silk, this was misleading to the public. It was a deception on every woman and girl of America every time they bought a pair of stockings. All those who admire beauty at least diaphanously adorned, will agree that we have today in this country ample and attractive demonstrations of the result of this conference. By the action of this conference, in voluntarily abandoning all deception, the industry has been honest with itself and has benefited both itself and the public.

Time does not permit further illustrations, but those already given, I believe, demonstrate that the Trade Practice Conference is the quickest, most direct, least costly, and most effective method known to the Government to prevent fraud, to promote honesty and fair dealing, and gives the greatest benefit to all.

Investigations

This is the day of reckless accusations, of unmeasured denunciation, of muck-raking and mud-slinging. A presidential election is approaching. This is the day when the self-anointed, the holier-than-thou, the reformer for pay, the fanatic and the crack-brained, the publicity lover and the professional patriot, are crowding for the spotlight. If you were to listen to the clamor today, you might believe that politics is a vast, putrid cesspool, and that the purity of those engaged in it is measured by the scandals that they can hold up to the public gaze. In such state of public hysteria, calm and just judgment is impossible. The innocent are as likely to suffer as the guilty; and the guilty are as likely to go free as the innocent. The country at present is cursed with a plague of self-seeking patriots, who are completely obsessed with the delusion that the road to the White House runs through a sewer.

But fortunately, this condition is but a temporary epidemic. It will largely pass with the election. On this wave of wide condemnation, the Federal Trade Commission has been paid the compliment of frequently being included.

Some of this criticism has been in connection with investigations. As to investigations by other bodies than the Commission, I am not now concerned. Investigations that are made upon alleged violations of law to uncover crookedness, I am not criticizing. Some of these investigations have no doubt been of great benefit to the public and some have done great public harm. But the responsibility of such investigations rests upon those who initiate them.

When the Federal Trade Commission is directed to make an investigation by the President or either House of Congress, if we have the authority of law to make it, I think we should make it fully, honestly and impartially, without fear and without prejudice; and that our findings should not to any extent be controlled by what the political effect may be.

As to investigations initiated by the Commission itself, the responsibility rests entirely upon the Commission. It must decide both as to its legal rights and as to the policy or the effect upon the public of such investigations.

The primal duty of the Commission is to protect the public from unfair and crooked practices. It is the duty of the Commission to protect honest business. It is the duty of the Commission to restrain and destroy dishonest business. These purposes should never be forgotten.

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The Crushed Stone Journal

J. R. BOYD, Editor

A. T. GOLDBECK, Director, Bureau of Engineering
The National Crushed Stone Association

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Many Engineers Attend Tennessee Meeting

THE Tennessee Crushed Stone Association held a most successful meeting of the crushed stone producers and highway engineers of Tennessee in the State Memorial Building Auditorium at Nashville on April 30. There were in attendance over sixty-five highway engineers from all over the State, including the Chief Engineer and his assistants; the Division and Construction Engineers and their assistants, and the Materials Engineers.

The feature of the meeting was an address by Mr. Goldbeck, Director of the National Association's Bureau of Engineering on "The Influence of Aggregates on Concrete Road Design," which was of very real interest to all of those present.

At the conclusion of the meeting fifty of the engineers present asked that their names be placed on the Association's mailing list to receive the Journal and Engineering Bulletins, which indicates the deep interest that these men are taking in the work of the Association and particularly that of the Bureau of Engineering.

We Can't Keep Up

NO matter how far ahead we may be planning our highways, no matter what our improvement of traffic facilities may be, we just can't keep up with the fast-speeding automobile.

There's the new Holland vehicular tunnel, for example. This pair of pipes under the Hudson river at New York has been devouring and ejecting automobiles for about four months. During that period nearly 2,500,000 motor vehicles of all types have passed through it.

Of course, the tubes can accommodate many more cars at a steady stream of about 25 miles an hour. But even now as they are, they show signs of clogging up when the big rush comes in summer. More tunnels are needed already. The new is aging fast.

The same is true of highways. Today we plan 100-foot highways, tomorrow they will have to be extended to 200 feet, and before long we shall have to build double-deck roads to accommodate slow and fast traffic.

The road we build today with prospect of accommodating for the next decade, may be overburdened in two years instead.

The automobile registration is growing faster than our highways and only radical and far-sighted planning can succeed in catching up with this growth.

—St. Paul News.

Cleaning and Repairing Cars

IT has been estimated that the annual cost to shippers using open-top car equipment, for cleaning and repairing cars placed at their plants for loading, is in the neighborhood of \$1,500,000 and the obvious question is why should the shipper bear this additional heavy burden of expense when it is the duty of the railroads to provide equipment which should need no cleaning or repairing?

It is entirely probable that if this matter is properly presented to the railroads, a very large reduction in this expense can be brought about.

With this thought in mind, the Association has recently sent to all crushed stone producers a questionnaire asking for information pertinent to this subject, as before going to the railroads, we must have complete and specific data.

It is our understanding that the National Sand and Gravel Association and the National Slag Association have also sent out questionnaires along this same line, and as soon as the necessary information has been received and tabulated, it will be possible to present a joint report to the railroads, which should materially strengthen our position.

We urgently request that every crushed stone producer give this questionnaire his immediate attention by promptly forwarding the desired information to our Washington Office.

Research Committee to Meet

THE Research Committee of the Association, on call of the chairman, John W. Stull, will hold its first meeting of the year in the offices of Mr. Goldbeck, Director of the Bureau of Engineering, on Friday, May 25.

The meeting has been called for the purpose of determining upon the projects which should first be undertaken by the research laboratory and also for the formulating of policies as regards the conducting of research and the publication of the results.

Excellent progress has been made in the purchasing and installation of equipment and it will be possible for the laboratory to get actively under way almost immediately after the meeting of the Research Committee.

The Federal Trade Commission

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It is the duty of the Government not to place on honest business any unjust burden. It is one of the highest duties of the Government to protect honest business from unauthorized investigating, meddling and snooping of its own agents.

Economic Investigations

I am utterly opposed to any investigation initiated by the Federal Trade Commission that is not based upon alleged violation of law.

One of the highest and most sacred rights of every honest business is the right to be let alone. It is as much the duty of the Federal Trade Commission to protect the citizen in his constitutional right of privacy as it is to prosecute him for his unlawful acts. I believe it is wrong and utterly unjustifiable on the part of the Federal Trade Commission to put any American citizen that is not accused of violating the law, to the annoyance, the expense, the discredit, the injury and the injustice of an investigation. The Federal Trade Commission has sufficient to do to control the crooked without prosecuting the honest.

I do not believe that the Commission has any legal right to make any investigation that is not based on alleged law violations. But if it did, to say that it is in the interest of the public to spend the public money for the purpose of having one division of the Commission make an ex-parte investigation of great industrial corporations for the sole purpose of telling those controlling such corporations how to run their business economically, is, to my mind, the ultimate in egotistical ignorance.

No Politics

Three years ago, in talking to this great organization, I promised that in so far as I could prevent it, the Commission should not be used to advance the personal or political fortunes of any man or party. I further promised that in so far as I could prevent it, the Commission should not be used as a publicity bureau to spread socialistic propaganda throughout this country. Those promises have been kept and I renew them again today.

The changes that were made soon after I went upon the Commission, which I recited to you in my former speech, in its practices and policies, have today the unanimous approval of the members of the Commission and are daily approved and endorsed. I am proud to say that the changes by the then Republican majority are today strongly approved and endorsed by the Democratic members. I am proud to say to you that in spite of statements and misrepresentations to the contrary, the determinations of the Federal Trade Commission today are absolutely free from any political bias or prejudice. There is no division along political lines in our decisions. I am proud to make this statement. I am especially proud to have the opportunity to say this to the public because of the recent statements, reiterated, emphasized and repeated, that the President has packed the Federal Trade Commission for political purposes.

A more baseless falsehood was never uttered by the polluted lips of slander.

Three years ago, I told you that the opposition to the changes in policies and practices of the Commission did not come from the Democratic Party, nor from the Republican Party, nor from business, nor from the taxpayer; but that it came from the beatific and vocal reformers that constitute the pink edges of both the old parties; that it came from those who look upon the world with a jaundiced eye; from those whose platform is expediency and whose political creed was that whatever is, is wrong; and especially from those who went up and down the land preaching that success and dishonesty are synonymous in American business.

The past three years have shown the correctness of the statement I then made, and it is emphasized today by the unanimous attitude of the personnel of the Commission.

The charge was then made that the effect of these changes in policy and procedure would be to favor the wrong-doer, and would be against public interest. After three years of trial the reply to that accusation is written in the records of the Commission. During

the last two years, or since the new policies have come into full practice, more crooked and dishonest concerns have been put out of business, the public protected from more fraud and swindles, the robbery of more victims prevented than in all the other twelve years of the life of the Commission added together. All criticism, all condemnation, all denunciation of the present policies by honest and informed men is by that record silenced forever. I point to the record and ask with confidence its approval by every good citizen of America.

Confidence in the Future

May I close this speech today as I began my speech three years ago? I then said I believe that the majority of the men and women conducting the vast business of this nation are honest and trying to obey the law. That faith abides with me today—strengthened by three years of experience.

Since I have been a member of the Commission more than 90% of all those accused, when told that they were accused of being guilty of unfair practices, immediately, and in good faith, of their own volition, abandoned such practices. What higher compliment can be paid to American business?

I do not believe that the pocketbook measures honesty.

I do not believe that either poverty or riches is inherently wrong.

I do not believe that either poverty or riches is a virtue.

I do not believe that success is a crime.

I do not believe that failure should be glorified.

I do believe that energy, industry, economy, integrity, capacity and brains must be recognized and rewarded if civilization is to endure.

I do not believe that poverty, idleness, dissipation, incompetency and weakness can be exalted if the race is to survive.

I believe that the greatest incentive to human endeavor is the certainty that everyone will receive the reward of his honest effort of either hand or brain. I believe that this is the consummation, the "far off divine event to which the whole creation moves."

We are told that nothing is created in vain—so I am constrained to suppose that there must be some use for the pessimist. My judgment is that the greatest blessing that the pessimist confers upon this world is when he quits it. I would rather be an optimist and be wrong, than be a pessimist and be right. I cannot and I do not believe that the great body of men and women today conducting the nations business is a vast army of potential crooks.

I know that it did seem for a time that the world war had broken up the very foundations of human civilization. But it is not so. The world still moves forward.

I still have faith in humanity.

I still have faith in men and women.

For every woman that falls there are hundreds that remain true—angels of purity and faithfulness.

For every man who betrays a trust, a hundred walk upright to the end—in spite of weakness, temptations and snares.

I still have faith in my country.

I still have faith in the institutions of my country.

I believe that there are more men and women ready at this very hour, if need be, to walk down to the dark, blood-besprinkled door of death to defend this nation of ours than ever before.

I still believe that the Stars and Stripes float over the grandest heritage of the human race.

The Bituminous Macadam Pavement

(Continued from page 13)

When applied, these asphalts shall be at such a temperature that they will readily flow on the road surface or be incorporated with the aggregate.

Finally, fine cover ($1\frac{1}{2}$ - $\frac{7}{8}$ in.) is spread over the surface at the rate of one cubic yard per 120 sq. yds. of surface and rolled thoroughly if asphalt OH-2 or tar TH has been used.

Final Appearance of the Surface

The above directions for both Method I (Double Penetration Method) and Method II (Triple Penetration Method) have been made with the idea that, if followed, the road surface will not have a heavy mat of bitumen on the surface, but, on the contrary, will have a mosaic appearance due to the coarse stone. This is considered an ideal condition and roads having this appearance quite generally remain free from any corrugations.

It will be noted that throughout the preceding description, *emphasis is laid on the necessity for attention to detail and the necessity for uniformity everywhere in every operation.* It is almost as easy to do the work with care as it is to perform the various operations in a neglectful manner and the results are far more satisfying. When properly constructed, bituminous macadam roads serve present-day traffic in a highly satisfactory manner. A number of bituminous macadam roads carrying heavy traffic have not required surface maintenance for many years and then only a surface treatment has been necessary.

